

REMARKS

Claims 32-44 currently appear in this application. The Office Action of November 5, 2002, has been carefully studied. These claims define novel and unobvious subject matter under Sections 102 and 103 of 35 U.S.C., and therefore should be allowed. Applicants respectfully request favorable reconsideration, entry of the present amendment, and formal allowance of the claims.

Specification

The specification is objected to as failing to provide proper antecedent basis for the claimed subject matter. The Examiner states that on pages 4-5 of the specification applicant does not clearly show the source of the oxidant and reductant species.

It should be noted that page 4, last paragraph, states that the electrochemically activated bactericidal aqueous solution may be prepared by electrolyzing an aqueous solution of a salt. Although the preferred salt is a chloride such as sodium chloride or potassium chloride, it should be appreciated that any type of soluble salt can be subjected to electrolysis to obtain the desired anions or cations. One skilled in the art can readily determine what salts are required to produce the desired anions, such as  $S_2O_8^{2-}$ .

Claim Objections

Claim 25 is objected to because of repetition of the term "HO<sub>2</sub>."

Claim 25 has been cancelled, and this term does not appear more than once in any of the newly submitted claims.

Rejections under 35 U.S.C. 112

Claims 17, 25, 28-29, and 31 are rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor, at the time the application was filed, had possession of the claimed invention.

This rejection is respectfully traversed. Claims 17, 25, 28-29 and 31 have now been cancelled. The term "predominantly...-containing solution" does not appear in any of the new claims. It is clear from the specification that the anolyte contains primarily anions and that the catholyte contains predominantly cations.

Claims 17, 19, 23, 25-29 and 31 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

This rejection is respectfully traversed. Claims 17, 19, 23, 25-29 and 31 have been cancelled by the present amendment and replaced by new claims 32-44. It is believed that claims 32-44 conform to all of the requirements of 35 U.S.C. 112.

With respect to the language that the solutions are "predominantly catholyte" or "predominantly anolyte", it should be noted that it is possible to mix the anolyte and catholyte solutions to any desired degree. However, for purposes of the present application, a catholyte solution is one that contains more catholyte than anolyte, and an anolyte solution is one that contains more anolyte than catholyte.

#### The Invention

The present invention provides a method for bactericidal treating bulk food storage container using an electrochemically activated aqueous solution. The solution is produced from two separate and independently harvested product streams, one of which is contains predominantly cations, the other of which contains predominantly anions. The electrochemically activated solution is produced by a through-flow electrochemical cell with two co-axial electrodes that are separated by a co-axial diaphragm so as to separate an inter-electrode space into a catholyte chamber and an anolyte chamber.

The applicant has discovered that there is a vast difference in characteristics and efficacy of an electrochemically activated (e.g., saline) solution if separate anolyte and catholyte solutions are produced, harvested, and applied as two separate product streams, either concurrently or successively.

By way of example, Japanese researches have shown that electrolyzed neutral water, including both anolyte and catholyte in one solution, is not effective against certain strains of bacteria, such as *B. subtilis* (see Horiba et al., "Bactericidal Effect of electrolysed Neutral Water on Bacteria Isolated from Infected Root Canals," *Oral Surgery, Oral Medicine, Oral Pathology*, vol. 87, January, 1999). However, applicant has discovered that anolyte produced according to the present invention, and harvested and applied as a separate product stream, is in fact effective against otherwise resistant strains of bacteria, including *B. subtilis*.

The two separate solutions, anolyte and catholyte, produced according to the present invention are unique in that they not only each have their own unique characteristics and applications, but they also have strong synergistic roles in some specific applications. More specifically, the present invention provides for production of two separate solutions which,

although they are extremely effective in killing and controlling harmful microorganisms, remain harmless to humans and animals. Through appropriate control of feed materials and production conditions, the anolyte and catholyte of the present invention, when compared to equivalent chlorinator products, tend to have a lower concentration of chlorine species and a higher concentration of host or other oxidizing radicals, which ensure greater efficacy because of this synergistic effect.

Furthermore, when it is required, for example, in food stuff applications, it is possible to produce products that are substantially free of chlorine.

The importance of the separate anolyte and catholyte solutions is advantageous in situations in which one does not wish to use chlorine because of damage to equipment or because of skin sensitivity. The anolyte produced according to the present invention not only permits total cleansing of surface areas, but has been demonstrated to be non-toxic and completely compatible with human tissue. Also, the anolyte produced according to the present invention has surfactant properties, which is important in removal and elimination of organics as well as in removal of biofilms.

The present invention involves use of a cylindrical electrolytic device having at least one electrolytic cell in which the anodic and cathodic chambers are separated by a semi-permeable membrane, the specific design of which makes it possible to produce two distinct, separate, and electrochemically different product streams of activated water, in a process known as electrolytic activation or electrochemical activation. More particularly, the electrolytic cell of the present invention, also known as a FEM-cell, or Flow-through Electrolytic Module, comprises a central rod, preferably used as the anode, around which a concentric ceramic tube diaphragm is arranged. The outer tubular wall of the reactor is then used as the counter-electrode. In this example, it would therefore be used as the cathode. The co-axial diaphragm separates an annular inter-electrode space between the two co-axial electrodes into a cathodic chamber and an anodic chamber, respectively. It is because of this particular electrochemical cell arrangement that cation-rich and anion-rich streams can be produced separate from one another and can be applied as two product streams, either simultaneously or consecutively. In addition, the electrochemical cell of the present invention provides for a much higher and more uniform electric field to which the solutions are

exposed. This provides for a higher level of "activation: of the solutions than that which is normally obtained with other types of electrolytic cells, particularly plate-type reactors.

The cation-rich and anion-rich solutions remain active for a limited period of time. Depending upon the solution, the activation status can extend from hours to days. The resultant meta-stable solutions, following decay of the state of activation, revert to substantially benign water with the composition of the feed.

Because of the nature of the electrochemical system used in the process of the present invention, the hydraulic flow path permits mixing of some catholyte back into the anodic chamber, or some anolyte back into the cathodic chamber. Because of the prevailing hydraulic regimes and the semi-permeable membrane, some degree of back-mixing occurs in the bulk streams, as well as of the individual ionic species. Accordingly, both types of species can be found in both streams, but in different amounts. Thus, neither solution is completely catholyte or completely anolyte, but each solutions is substantially either a catholyte or an anolyte.

It should be noted that the catholyte is a negatively charged fluid stream, although it contains positively charged cations such as  $\text{Na}^+$  and  $\text{Ca}_2^+$ , while the

anolyte is a positively charged fluid stream, although it contains negatively charged anions such as  $\text{Cl}^-$ .

In Electrolytic Activation, water of varying degrees of mineralization is passed through the cylindrical electrolytic cell, the specific design of which permits production of two distinct and electrochemically different streams. The design of the specific electrolytic cell used in the present invention is such as to ensure a uniformly high strength electrical field through which each micro-volume of water must pass. This electric field created in the cylindrical cell has a high potential gradient and results in the creation of solutions of which the pH, oxidation/reduction potential, and other physico-chemical properties lie outside of the range that can normally be achieved by conventional chemical or most electrolytic means.

During electrolytic activation in the electrolytic cell used in the present invention, three broad classes of product are believed to be produced:

1. Stable products. There are acids (in the anolyte) and bases (in the catholyte) that influence the pH of the solution in question, as well as other active species;

2. Highly unstable products. These include free radicals and other active ion species with a half-life to typically less than 48 hours. Included here are

electrically and chemically active microbubbles of electrolytic gas, 0.2 to 0.5 micrometer in diameter, and in concentrations of up to  $10^{-7}$ /ml, distributed uniformly through the solution. All of these species serve to enhance the oxidation-reduction potential of the anolyte and catholyte.

3. Quasi-stable structure. These are structures formed at or near the electrode surface as a consequence of the very high voltage gradient (106V/cm) in those regions. These are free structural complexes of hydrated membranes around ions, molecules, radicals, and atoms. The size of these water clusters is reduced from about 13-18 to approximately 5-6 molecules per cluster. All of these features enhance the diffusion, catalytic, and biocatalytic properties of the water.

It should be noted that the level of mineralization of input water required to generate optimally metastable solutions is insignificantly different from the composition of potable water. However, the heightened electrical activity and altered physico-chemical attributes of the solutions differ significantly from the inactivated state, yet they remain non-toxic to higher life forms. Without maintenance of the activated state, these diverse products degrade to the relaxed state of benign water and the anomalous

attributes of the active solutions, such as altered conductivity and surface tension, similarly revert to pre-activation status.

Conventional technologies using electrolytic activation to generate biocidal solution have not been capable of separating the anolyte and catholyte solutions during production in the cell. In these technologies, the two opposing solutions have greatly neutralized each other with respect to potential electrical activity.

In contrast thereto, the electrochemical system used in the present invention, for example, with sodium chloride, generates a chloride-based anolyte that is up to 300 times more effective than the sodium hypochlorite generated by earlier systems. Additionally, comparison of a neutral anolyte with alkaline glutaraldehyde, pH 8.5, showed that the latter required a concentration of 2% vs. a concentration of 0.05% of the former, in order to achieve the same biocidal efficacy. Similarly, it has been shown that a 5% solution of sodium hypochlorite can only be used for purposes of disinfection, while a 0.03% solution of neutral anolyte that has both sterilizing and disinfecting properties, is sufficient.

Thus, using non-toxic salts, one can produce activated solutions which exceed chemically derived equivalents both in low dosage effectiveness and physico-

chemical properties. This heightened biocidal capacity, relative to traditional chemical solutions, permits the incorporation of activated solutions at substantially lower dose rates which, besides the previously mentioned advantage of eliminating the risk of toxicity and adverse environmental impact, also offers cost effective solutions.

#### Art Rejections

Claims 17 and 22-31 are rejected under 35 U.S.C. 102(b) as being anticipated by Doi.

This rejection is respectfully traversed. Doi teaches a process for treating water electrolytically in an electrolytic cell without a diaphragm between the cathode and the anode. This is entirely different from the process of the present invention, wherein there is a diaphragm between the cathode and the anode so as to separate an inter-electrode space into an anolyte chamber and a catholyte chamber.

It is well known to produce electrochemically activated solutions such as those produced by Doi. However, these solutions are not nearly as effective as the solutions produced by the method of the present invention. By electrochemically activating a salt solution in a through-flow electrochemical cell under the condition claimed herein, the solution gains very

specific properties that are different from and far superior to conventional bactericides, disinfectants, or sterilants.

Doi is silent with respect to diverting some or all of the anolyte or catholyte through the counter-electrode chamber. Doi describes a conventional method for dividing a feed solution into two streams, sending one stream through the anodic chamber and the other stream through the cathodic chamber. In contrast thereto, the present invention calls for sending the entire feed through one electrode chamber, and thereafter recirculates all or part of the electrolyzed solution through the other electrode chamber. It is because of this preparation arrangement that the present invention makes it possible to modulate the respective characteristics of the anolyte or catholyte, such as pH and oxidation-reduction potential.

As noted above, the process of the present invention produces two separate streams of activated solutions, namely, anolyte and catholyte. Depending upon the production methods used and condition of the device, the anolyte typically can have a pH in the range of 1.5 to 9, and an oxidation-reduction potential of approximately +150 mV to +1200 mV. The anolyte contains a mixture of oxidizing free radicals, and has an

antimicrobial effect. The catholyte produced typically has a pH in the range of 8.5 to 13, and has an oxidation-reduction potential of about -150 mV to -900 mV. The catholyte has reducing and surfactant properties and is an antioxidant.

One of the advantages of the system of the present invention is that the chemical composition of the two solutions can be altered by using various hydraulic flow arrangements, linking electrolytic cell modules in various configurations in order optimally to address the requirements of specific areas of application. Other variables included flow rate, hydraulic pressure, concentration, temperature, current density, and voltage on the electrodes.

Some or all of the negatively charged antioxidant catholyte can also be channeled back into the anodic chamber, thereby modulating the quality of the positively charged oxidant solution, *i.e.*, the anolyte that is produced. Similarly, some or all of the positively charged oxidant solution, *i.e.*, the anolyte, can be channeled back into the cathodic chamber, thereby modulating the quality of the catholyte. Depending upon the specifications of the required application, variations in the design of the hydraulic systems can be effected or implemented to meet the requisite objectives.

It is precisely because of the manipulation feature of the system of the present invention, and the vast range of possibilities for properties of the solutions produced, that the process of the present invention produces electrolytically activated solutions with specific properties. However, it is also because of the ability to produce so many different solutions with different electrical properties, that it is not obvious to use an electrolytically activated solution that can be used in different applications.

The properties of the electrolytically activated solutions of the present invention depend upon a number of factors, including the solution flow rate through the cell, type of salts, voltage and current applied, temperature, inter-flow dynamics of the solutions between the anode and cathode chambers, such as degree of feedback of catholyte into the anodic chamber, the design and geometry of the cell, and the degree of mineralization of the water.

Another difference between the present invention and Doi is that Doi produces in a single chamber and uses electrolyzed solutions in a mixed form. The present invention makes it possible to produce and harvest two separate electrolyzed solutions on a continuous and demand-driven basis.

It is well known in the art that pH increases when hydrochloric acid is converted to hypochlorous acid (Doi, page 4, lines 38-39). However, it is also well known in water treatment chemistry that the microbial efficacy of hypochlorous acid is directly dependent on pH; its efficacy increases with a reduction in pH. Accordingly, the assumption of Doi that "bactericidal action produced by the anode remains unaffected" is inaccurate—the efficacy will in fact decrease because of the increased pH.

The process of the present invention, however, does not produce hypochlorous acid *per se*, but rather produces a cocktail of several oxidizing agents, such as oxygen free radicals, chlorine dioxide, ozone, peroxide radically, hydroxyl radicals, and the like. Because of the many oxidizing agents in the solution of the present invention, the solution is not nearly as pH dependent as Doi's solution and works equally well over a range of possible pH values. Nonetheless, because it is used primarily around foodstuffs, the anolyte of the present invention is preferably produced at a neutral pH.

Thus, while the Examiner's statement that "Doi teaches the use of an electrolysis device which inherently produces a predominantly cation-containing solution" may be accurate with respect to pH

consideration and hydrogen ion concentration of a solution, one must also consider the following facts. An analysis of a full ionic balance and electrostatic charge balance of an acidic solution, electrolyzed as described by Doi, will reveal that although it is acidic with respect to pH and has a net excess of hydrogen ions, it is in fact ionically balanced, having been produced and harvested as a mixed ion electrolyte. The solutions produced in the present invention, having been produced and harvested separately, are not in a state of ionic balance and in fact to have a predominance of presence of cations in the catholyte and anions in the anolyte.

Claims 18-21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Doi.

This rejection is respectfully traversed. While Doi produces ice from the solution which had been electrolyzed together, the present invention uses a solution that may be predominantly anolyte, predominantly catholyte, or any mixture of these solutions. With respect to the "small amount" of salt Doi adds for the electrolysis, it should be appreciated that it is necessary to avoid producing chlorine, which would result from electrolysis of sodium chloride. Applicants have found an optimal balance between efficacy and the

unwanted presence of chlorine by using a salt solution of from 3 to 10%.

As noted above, one of the primary advantages of the present invention is that by using electrochemical activation, one can produce, harvest, and apply, either simultaneously or consecutively, two distinct solutions (catholyte and anolyte), and the chemical composition of the solutions can be altered for different applications by using a variety of hydraulic flow arrangements, linking electrolytic cell modules in various configurations, and by manipulating *inter alia*, flow rate, hydraulic pressure, salt concentration, temperature, current density, and voltage on the electrodes. More specifically, some or all of the catholyte can be channeled back into the anodic chamber, thereby modulating the properties of the anolyte that is obtained. Similarly, some or all of the anolyte can be channeled back into the cathodic chamber to modulate the properties of the catholyte that is produced. Depending upon the requirements of the individual situation, variations in the design of the hydraulic systems can be affected or implemented to meet the requisite objectives. This manipulation feature of the electrochemical system used in the present invention and the vast range of possible solutions makes it possible to produce an

electrolytically active solution with very specific properties.

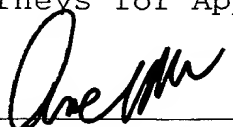
With respect to the Examiner's comments regarding the higher and more uniform electric field, this limitation is not recited in the claims because it is an inherent feature of using the electrochemical system of the present invention. Likewise, the environmentally friendly aspect of the invention is not included as a limitation in the claims because this feature is inherent in the claimed process.

In view of the above, it is respectfully submitted that the claims are now in condition for allowance, and favorable action thereon is earnestly solicited.

Respectfully submitted,

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